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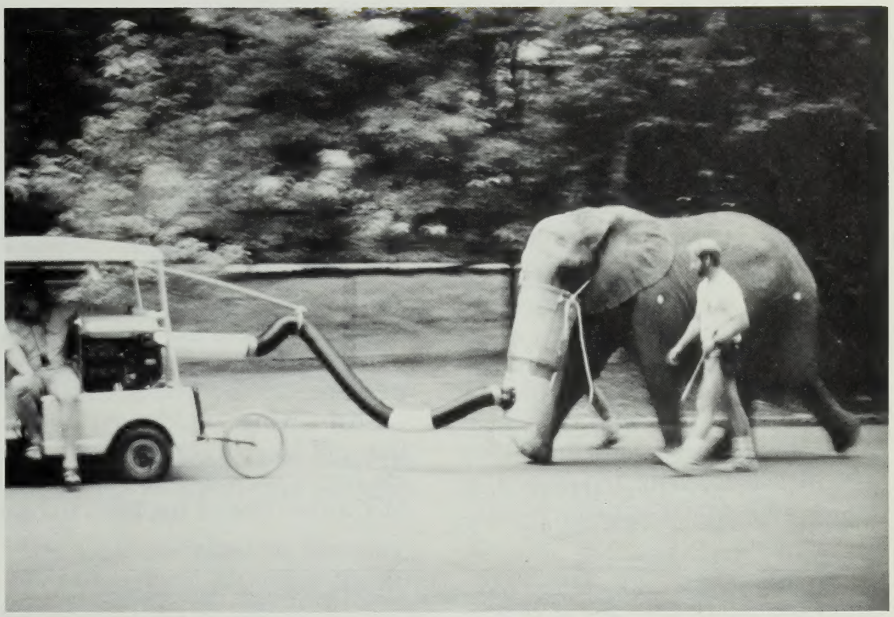
MCZ newsletter
MUSEUM OF COMPARATIVE ZOOLOGY

Elephants Surprise Researchers

Given their long legs and large size, one would expect that elephants would walk faster and on a pound-for-pound basis cheaper (in terms of energy consumption) pace than we do. Recent measurements by a group from the MCZ's Concord Field Station show that this is only partially true—elephants walk more cheaply but not faster. This result completely stumped researchers, who devised an ingenious method to measure elephants' oxygen consumption while walking, as it contradicts current accepted principles governing the metabolic cost of walking.

The research project was instigated by MCZ Research Associate Dr. Vaughan Langman, now at Louisiana State University. He has long been interested in how large animals thermoregulate in the hot climates they inhabit. Camels cool off at night to 5% below their normal body temperature, and thermal inertia causes them to stay cool well into the day. Langman thinks elephants do the same thing. In an ongoing study at Zoo Atlanta, he measures animals' temperature throughout day and night.

A large contingent from the Concord Field Station got involved in the study last summer to measure the rate of energy consumption by elephants during walking. The team included Dr. C. Richard Taylor, Concord Field Station Director, Dr. Geoffrey Maloiy (Duke University) postdoctoral fellow Jean-Michel Weber and graduate students Tom Roberts and Rodger Kram. Three young African elephants were trained and handled by Jim Black and his assistants at Zoo Atlanta. Each elephant wore a "gas mask" and followed behind a motorized golf cart while oxygen consumption and speed were measured. The gas masks were extra-large garbage cans which fitted neatly over the trunk and mouth. The elephants were content as long as a steady supply of carrot chunks was tossed into the mask. A wide hose was connected to a hole in the bottom of the can to a ventilator carried on the cart. The ventilator pulled fresh air through the mask at controlled rates so that oxygen consumption could be measured.



Young elephant going through its paces.

In one week the team was able to get conclusive results which were entirely counter-intuitive. Expecting that the elephants minimum cost per mile would be at a high speed, they found instead that it occurred at only three miles per hour. These results are giving rise to a whole new line of inquiry about what sets the cost of walking. This may involve importing elephants to the Concord Field Station for prolonged studies of locomotion, reproduction, and thermal physiology. The elephants would complement the current population of dogs, goats, coyotes, llamas and emus that are currently being studied at the facility.

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McCarthy and the Study of Global Change

For the last three years, Dr. James J. McCarthy, Director of the MCZ, has chaired a committee that has responsibility for defining the critical elements of a program known as the International Geosphere-Biosphere Program, or more generally by its subtitle, Study of Global Change. This committee, consisting of 18 members from 15 nations, was formed to look broadly at the earth system, and to identify the key unknowns that lie at disciplinary boundaries between biology and other disciplines, that require a global approach to study effectively, that are likely to change on decadal to century time scales, and that are most susceptible to human perturbation.

During the past three years the Global Change committee has organized 50 meetings involving 500 scientists from 40 nations. Their purpose has been to explore in detail the key problem areas identified by the committee, to build consensus regarding priorities, and to develop specific science plans and associated strategies for their implementation. The secretariat for this program is in Stockholm, where it is hosted by the Swedish government and the Swedish Royal Academy of Sciences. And although several meetings have been held in Boston and Stockholm, others have taken McCarthy to many cities in Europe and Asia, including Beijing, Berlin, Brussels, Budapest, Lisbon, London, Moscow, Paris, Rome, Sofia, and Tokyo. In the course of this work he has met with the science advisors for Mrs. Thatcher, Messrs. Bush, Gorbachov, and Mitterand, and with a small group convened to discuss global environmental problems with Pope John Paul II.

Nearly 50 nations have now formed their own national committees for this program, typically through structures of national academies of science or royal scientific societies. In the U.S. this committee, referred to as the National Research Council Committee on Global Change, is chaired by Professor H. Mooney of Stanford and its members include, in addition to McCarthy, two of his Harvard colleagues, Professor Michael McElroy of the Department of Earth and Planetary Sciences and Professor William Clark of the Kennedy School. McElroy, Clark, and McCarthy participated in the MCZ-sponsored symposium on Global Change in the spring of 1989.

The activities of the Global Change committee are supported by voluntary contributions from participating nations through their national committees, from the Mellon and Rockefeller foundations, IBM and Dutch Shell. The nation making the largest cash contribution is Sweden, but remarkably, the USSR is a close second, followed by the U.S. and Japan. The U.S. is, however, the largest contributor when indirect sources, including temporary personnel transfers, are considered.

The program has produced several resports. During the summer of 1990 the committee released a major report summarizing the key research priorities and formulating ten research projects that address these priorities. The plan is to launch these projects in the 1990s, in concert with a set of projects under the auspices of a companion international program, the World Climate Research Program. The chairman of this latter program and McCarthy have worked together very closely to integrate fully studies of biological and biogeochemical processes with the physical processes of climate.

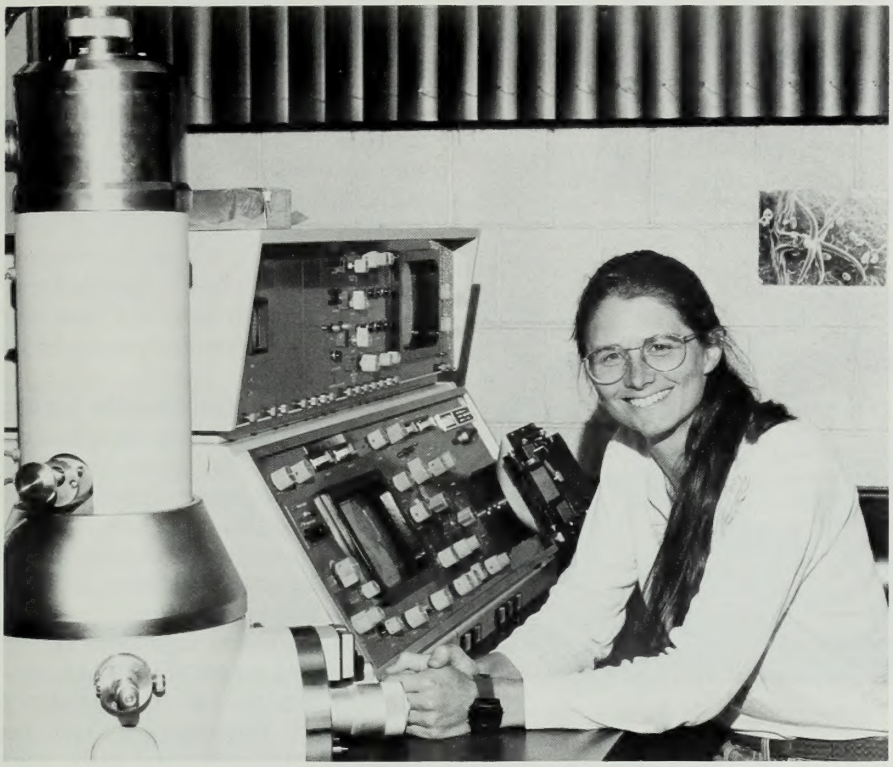
In fact, they are the co-authors of the final chapter of the UN report on climate change that was recently released and has been very much in the news in the last few weeks. Their chapter, titled "Narrowing the Uncertainties," addresses the key unknowns in the climate system. This includes not only issues relating to the effects that increasing concentrations of so-called "greenhouse gases," such as carbon dioxide, could have on climate, but also the important role that terrestrial and marine organisms play in global cycles of these substances. It offers a model for research in the next decade that, if implemented, would improve the

(Continued on next page)

Present distribution of National IGBP Committees (May 1990).

Argentina
Australia
Austria
Bangladesh
Belgium
Bolivia
Brazil
Bulgaria
Canada
Chile
China (CAST)
China (Academy in Taipei)
Colombia
Czechoslovakia
Denmark
Egypt
Finland
France
German Democratic Republic
Federal Republic of Germany
Greece
Hungary
India
Ireland
Israel
Italy
Jamaica
Japan
Kenya
The Netherlands
New Zealand
Norway
Peru
Poland
South Africa
Sweden
Switzerland
Sri Lanka
Thailand
United Kingdom
U. S. A.
U. S. S. R.
Venezuela
Zimbabwe

Robin Pinto New SEM Research Technician



"The SEM is a real joy," declares Robin Pinto, who is now running the MCZ's scanning electron microscope facility on a half-time basis. "I get to see such a wide variety of different research projects. On Friday Fuzz Crompton was down looking at three million-year-old marsupial teeth; a researcher from Southeastern Massachusetts University was examining two million-year-old diatoms for a dry lake bed in Kenya trying to reconstruct the paleoenviroment of Kenya (it was wet, low-lying marsh); and Richard Norris, a former student of Steve Gould's and now at Wood Hole Oceanographic Institute, was studying million-year-old foraminifera collected from open-ocean-sediment deposits from deep-sea drilling operations."

The other half of Pinto's time is spent assisting Professor Robert M. Woollacott with his marine biological research in microscopic reorganization of marine invertebrate larvae.

Pinto operated both scanning and transmission electron microscopes while doing research for her M.S. in Biological Oceanography from the University of California at Santa Cruz.

She was interested in how one-celled organisms survive in the nutrient-poor water of the North Pacific Gyre (north of Hawaii). In this oceanic, desert-like environment some protozoans provide their own nourishment by creating an internal garden with the help of symbionts—a single cell algae or photosynthetic bacteria. If the host animal stays within the sunlit portions of the water column, its symbionts will produce sugars through photosynthesis and subsequently leak those sugars to its host. In return, the host provides a sheltered environment free from predators. One of the questions that puzzles researchers is how the symbionts get established inside the host. One theory that has been proposed is that the animal swallows a symbiont, and then (possibly because of some chemical signal) does not digest it. This strategy of creating an internal garden appears to be a nutrient-poor adaptation because studies of the same or similar species in nutrient-rich near-shore environments revealed that they have no symbionts.

The SEM is located in Room 103 in the MCZ Labs; appointments should be made by calling 495-4137; rates are $25 per hour for Harvard staff and students and $40 and $35 for the first and consecutive hours for researchers outside of Harvard. Current lead time for appointments is two to three weeks.

McCarthy
(Continued from p.2)

precision of predictive efforts related to climate and global change.

The initial planning phase for this international program is now complete, and the implementation phase has begun. One project of this program addresses the role of ocean plankton in the global carbon dioxide cycle, and certain aspects of it are central in the research activities of McCarthy's laboratory in the MCZ.

His team of reseachers were involved in the first field campaign of this international study in the North Atlantic last year. They joined the expedition in the Azores and worked northward to Iceland, concentrating on a region of intense plankton blooms that occur every year in spring. Other investigators on research vessels from England, Germany, the Netherlands, and Canada participated in this highly coordinated study.

A new committee has now been formed to guide the implementation of the Global Change Study, and McCarthy has agreed to chair this group for the next two years. In some respects this next phase will not be as intensive as the planning phase, because responsibilities for implementing the first five of this program's projects are being coordinated by five different nations. Nevertheless, the new committee must see that these separate components are fully integrated, and will continue to refine the science plans for an additional five projects to be launched later in this decade.

Ants and Wasps: Investigating their Reproductive Strategies

Kern Reeve (l.) and Laurent Keller

Why does one queen wasp stay around and help another queen raise her brood? Why do some ant colonies in the same species have one queen while others have several? To answer to these questions and a host of other related puzzles, two post-doctoral students working with Professor E. O. Wilson recently established themselves, by happy chance, in the same lab in the Social Insects Department of the MCZ Laboratories.

H. Kern Reeve, a member of the Society of Fellows with a Ph.D. in behavioral ecology from Cornell, is researching "what kinds of patterns of cooperation and conflict exist within insect societies as a consequence of the genetic structure of the colonies." His colleague, Laurent Keller, hails from Switzerland, where he earned a Ph.D. from the University of Lausanne. With a two-year grant from the Swiss National Foundation, Keller will examine how variation in the number of queens in a given colony affects their reproductive strategies and success.

While Reeve studies a social wasp of the genus *Polistes*, which has relatively few individuals in each colony, and while Keller studies the fire ant *Solenopsis invicta*, the nest populations of which can number millions, their work overlaps in basic ways. In both cases their research is aimed at testing and developing a general evolutionary theory regarding animal behavior.

The original version of this theory holds that every organism strives to propagate and increase representation of its genes within the population gene pool. In an extension of this theory, William Hamilton postulated that reproductive behavior—and behavior in general—is governed in part not only by its effect on direct offspring, but also by its effects on the numbers of offsprings produced by relatives. Thus, the worker bee, in an oft-cited example, will sacrifice itself to defend a nest, the members of which share many of its genes.

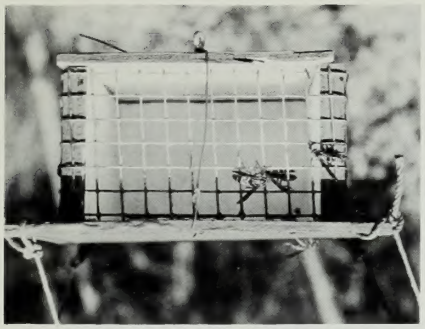
Fire ant queens stay close to their brood and are constantly groomed by workers.

In the case of *Polistes*—the highly social common wasp that builds combs under the eaves of buildings—two or more females, one dominant and the other subordinate, will often found a nest together. One crucial question for Reeve is why does the subordinate queen help the dominant queen to reproduce rather than starting a nest of her own. Another question is what determines how much reproduction will be yielded by the dominant to the subordinate.

The key, he believes, lies in their degree of relatedness. "In some colonies," he says, "where the subordinates are more highly related to the queen, it's theoretically predicted there will be a greater skew of reproduction in the dominant's favor." That's because the dominant's offspring are related closely enough to the subordinate to make it advantageous for the latter to remain and help with raising the dominant's brood.

To test this theory, Reeve is combining field work with DNA fingerprinting, a technique he learned while studying naked mole rats, whose colonies resemble those of social insects. To do this, he extracts the DNA from an individual, cuts it with chemical scissors in a process which allows him to assess "the precise genetic structure and pattern of kinship within a colony."

Both Keller and Reeve emphasize that "plasticity" plays an important part in their research on social insects. Plasticity is another word for variation within a species in terms of everything from size to behavior to queen number. "I'm very interested



Spring queens of the paper wasp, Polistes fuscatus, *searching for a suitable nest site in an observation box.*

in plasticity and how it affects reproduction," says Reeve. "Many people in my area have a typological view: this species does this, that species does that. I want to look at variation in reproductive dominance within a species and relate it to a number of factors—relatedness, fighting ability, time in the colony cycle, food supply, etc."

This plasticity is quite evident in the colonies of S. *invicta* Keller is studying. Although they are the same species, the worker ants and female sexuals (sexuals are queens and males capable of reproduction) in colonies with one queen are significantly larger than those in colonies with several queens. Indeed, plasticity is integral to the research being done by Keller, whose hands and arms are tracked with myriad bites from the fire ants in keeps in colonies in the lab. He studies "the consequences of queen numbers on the life history of the species." More specifically, he is researching "the influence of queen numbers on the reproductive success of queens—how many offspring they produce and how many of the offspring turn into sexuals or workers."

According to Keller there are many species of social insects—ants, wasps, bees, termites—that have colonies with several queens. Of high interest is the case of *S. invicta*, which exhibits two different forms, one with colonies headed by single queens and the other with colonies containing up to hundreds of queens. This has consequences both for queens and for the nest as a whole. "If several queens are reproducing which are not highly related," he says, "workers will not be highly related either. This may cause conflict within a colony.

On the other hand, there may be advantages, such as genetic diversity, to having more than one queen. What Keller hopes to determine are the relative advantages of being a single queen in a colony versus being one of several queens in a colony.

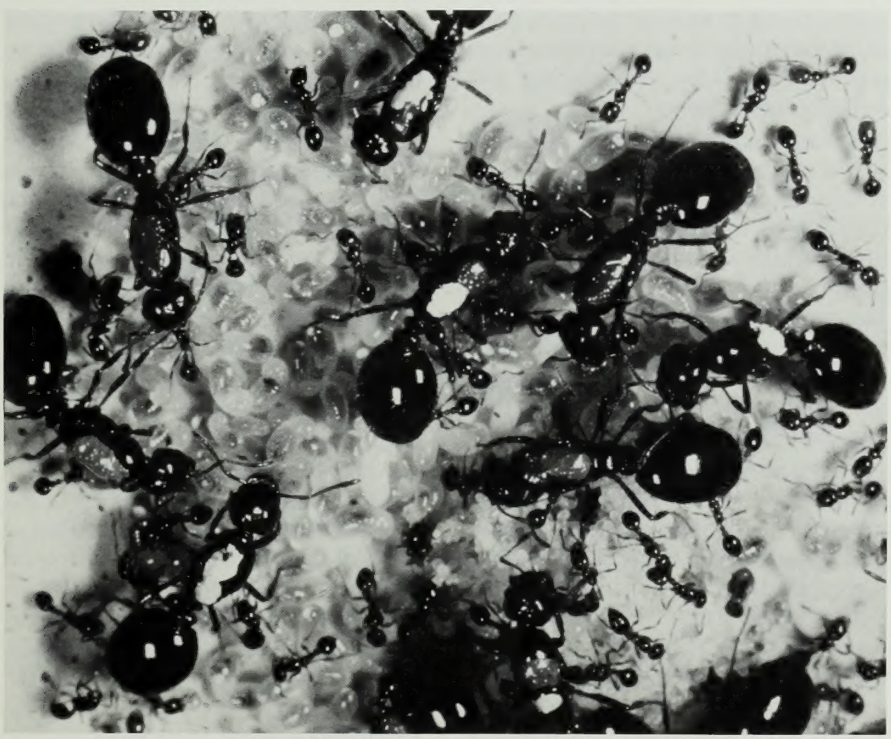
He is finding, generally, that the more queens in a nest, the fewer offsprings they produce and the fewer of them that develop into female sexuals. However, those that do develop have a higher probability of surviving because they adopt other reproductive strategies such as starting new colonies. Female sexuals produced in colonies with several queens may also return to the mother colony or another colony where there are workers to defend them against predators.

In contrast, female sexuals in colonies headed by single queens suffer a high mortality just after mating because they start new nests without the help of workers.

To determine whether the basis underlying this reproductive difference is genetic or environmental and to investigate the reproductive success of queens in each of these two forms, Keller "tags" the eggs laid by queens that can be identified by the help of genetic markers. Then, by manipulating his colonies and raising eggs laid by different kinds of queens, Keller is able to assess how much the contrasting behavorial and morphological traits of the two forms are genetically mediated or result from the type of colony in which the individual ant is raised.

It's a process, that, as his hands and arms attest, involves a certain amount of real contact with the objects of his research.

While the sharing of a lab was coincidental, both researchers expect to benefit from each other's research over the next couple of years. As Reeve says, "A unifying theme is understanding the partitioning of reproduction and reproductive success of different queens within colonies, and we hope that by comparing our systems we can extract some general principles or general theory about how ecological and genetic factors shape the patterns of reproduction."



Keller marks his fire ant queens with paint dots so they can be individually recognized.

How Whales Feed Poses Many Questions

Alex Werth

Pity the whale biologist! A beachcomber of necessity, he cannot order his specimens from a biological supply house not only because of size, but because all whales are highly protected by the Marine Mammal Act of 1972. Instead, he has to wait for time and tide, and then when a specimen does wash up, which happens rarely, it is often so odoriferous that extended study demands great intestinal fortitude.

Graduate student Alex Werth, despite these obstacles, is making substantial progress in his study of how ceatceans feed. He has looked primarily at odontocetes (toothed whles, dolphins, and porpoises), which are interesting because in many species the teeth seem to have little or nothing to do with prey capture. In fact, some "toothed whales" have no teeth at all! Whales with broken or deformed jaws, or teeth that are worn down or covered with barnacles still manage to feed normally. In other odontocetes only the males have teeth. These appear to be a secondary sexual characteristic such as the antlers of deer, and are used for fighting. A good example of such a tooth is the long, spiralled tusk of the narwhal; female narwhals only rarely have tusks but have no trouble feeding.

Werth has also learned that the dentition seen in prepared skulls can be misleading, since the teeth of some dolphins never erupt, even in adults. Thus he is wary of relying solely on bone material in his research.

Instead of grasping the fish and squid that they eat with their teeth, as has traditionally been thought, "toothless" odontocetes, Werth believes, actually suck in their food, as many fish do. This mode of ingestion might explain why debris such as rocks, shells, branches, coconuts, and other odd refuse and assorted bottom dwelling creatures are frequently found in whale stomachs. Since whales swallow their food whole without chewing it, the complex, compartmentalized stomach aids in mechanical digestion.

Werth is investigating how odontocetes feed through films, experiments, and observations of captive animals, as well as by dissection of stranded animals at the New England Aquarium.

The mysticetes or baleen whales, so named because of the long plates and fringes of baleen ("whalebone") which hang from their palates, feed in an entirely different manner than odontocetes. It is a method not yet entirely understood.

Actually, there are three different ways of feeding: the right whales slowly skim small zooplankton from the surface; the rorquals (such as the blue and fin whales) lunge and gulp up mouthfuls of shrimp or fish; and the gray whale sucks its food off kelp or the sea floor. But in all cases the baleen acts as a sieve which traps the food in the mouth when water is expelled.

This much is known, but the big mystery is the mechanism by which mysticetes get food off their baleen. The question has been posed for centuries, and the standard answer is that whales scrape the food off with their tongues. Yet rorquals in particular have very loose, floppy tongues that can scarcely be elevated. A strong possibility is that whales use suction to pull in water and "wash" the food onto the tongue. Werth also thinks that observations of feeding right whales shaking their heads from side to side might be another explanation, as the whales could employ this motion to dislodge food from the baleen.

Opportunities to examine whales up close are rare and exciting events. In January of 1989, a two-day-old northern right whale, which had been spotted the previous day with its mother, washed up on the beach at Cumberland Island, Georgia. It was frozen and shipped to the New England Aquarium in Boston, which keeps a larger freezer full of "beach kills." During an extended necropsy session, Werth dissected the massive 100 pound, three-foot tongue and its surrounding musculature.

This impressive structure had never been examined in detail, and Werth would like to use his anatomical data to describe the role of the tongue in right whale feeding, especially since it would be impossible to freeze and carefully dissect an adult tongue. However, he is unsure what functional conclusions he can draw from this specimen since a neonate would be too young to feed normally and its tongue would be used for sucking. Nevertheless, he surmises that the predominance of some muscles explains the lateral sweeping motion of right whale tongues seen in underwater films; this action probably channels food-laden water onto the racks of baleen.

The skeleton of this young whale will probably end up in the Mammal Department collection at the Concord Field Station in Bedford, along with many other cetaceans donated by the New England Aquarium.

Another potential source of whale tongues lies in Barrow, northern Alaska, where the local population still practice subsistence hunting on bowhead whales. Since bowheads are the closest relatives of right whales and because these tongues can be easily frozen, Werth plans to work on some Barrow specimens in his ongoing investigation of how the largest mammals in the world feed themselves.

New Fishes from the Congo

An expedition to Lake Telle, in the Likouala rainforest, People's Republic of Congo by four researchers has resulted in the addition of several new fishes to the MCZ's ichthyology collections. These include killi fishes, electric fishes, cichlids, lungfish, anabantids, and tetras.

Dr. Phillip Lobel, former MCZ graduate student and now Associate Scientist at Woods Hole Oceanographic Institute, was joined by Dr. James Moore, former graduate student in Harvard's Department of Anthropology and now Assistant Professor at the University of California, San Diego, Dr. Carole Sussman, also an anthropologist from Harvard now at UCSD, and Elisabeth Kalko of the University of Tubingen on this expedition with the primary objective to collect all the fishes from Lake Telle. Additional projects included a biological survey of the Likouala rainforest, a study of native knowledge and lore about wildlife in the region, and an opportunity for field experience for some Congolese wildlife biologists and Bometaba tribespeople who took part in the expedition.

This was the second MCZ scientific exploration of the region—the first was undertaken by Lobel and Dr. Gary Alpert in 1987 and resulted in the collection of several species of ants that are currently being studied at the MCZ and other institutions. Various amateur forays have been mounted in vain search of the legendary creature Mokele mBembe, the Congo's version of the Loch Ness monster. The group's report makes recommendations for long-term conservation efforts and for follow-up studies of the region. Partly on the basis of recommendations from this expedition, the Congolese government is currently considering designating the area a national park.

Photos by Elisabeth Kalko

Phillip Lobel learns local fish names and lore from Congolese natives.

Mormyrops, a new species of fish collected from Lake Telle, Congo.

Staff Notes

Dr. Edward O. Wilson, Baird Professor of Science and Curator of Entomology in the MCZ, has been elected for Foreign Membership to the Royal Society, London and to the Finnish Academy of Science and Letters. He has received five additional awards in 1990. These include the Crafoord Prize of the Royal Swedish Academy of Sciences; the Prix du Institut de la Vie, Paris; the Distinguished Scientific Humanist Award, the Council for Democratic and Secular Humanism; the Revelle Medal, San Diego Natural History Museum; and the Gold Medal of the World Wide Fund for Nature (WWF-International). In presenting the latter award, His Royal Highness the Duke of Edinburgh, International President of WWF, commended Wilson "for his scientific studies and innovative thinking which have opened new horizons on biology and evolution, for his conservation philosophies that relate people to the rest of the natural world and for his communcation skills which have drawn world attention to the critical need to preserve biological diversity."

The Museum Guide Program

More than 30 volunteer guides continue to provide educational programs to visiting school and adult groups. Several guides are currently working on a program to take place in the new Native American Hall with Roxanne Reddington-Wilde of the Peabody Museum and Maureen Stephens.

Museum Guide Training

Ongoing training sessions are being held monthly and a series of training sessions for new guides will be held in January led by Winifred Eisan. Those interested should apply to Maureen Stephens at 617-495-2341.

Children's Programs

The response to our children's after-school and Saturday morning classes programs has been enthusiastic. In fact, one program was oversubscribed and resulted in two sections being offered. Several classes will be offered in the spring.

Travel Program

This winter's cruises to Antarctica, Indonesia, and Patogonia, in association with Harvard Alumni Association, still have some room. The Galapagos trip in January has a waiting list, and the expedition to Belize and Tikal in February is nearly filled. Kenya Under Canvas with Drs. Farish A. Jenkins, Jr. and Kenneth Dial will be going as planned but our other winter Africa departures have been cancelled due to low enrollments. Papua New Guinea in March, in association with Harvard's Peabody Museum, still has room.

We have added two exciting programs for March: a one-week spring break get-away to the Sea of Cortez on the *Sea Bird* accompanied by Dr. Robert M. Woollacott, and a cruise on the *Polaris* through the Panama Canal, to San Blas Island, Bonaire, Trinidad, Tobago, and three days on Venezuela's Orinoco River accompanied by Dr. Randy Olson, a former Harvard graduate student, now at the University of New Hampshire.

Photo by Gabrielle H. Whitehouse

The Catalina on Lake Tanganyika with boats used for landing to camp and trek chimpanzees.

Aviation buffs and Africa afficionados have a rare treat in store. Based on a reconnaissance trip this summer we have decided to offer a most unusual Africa safari aboard ZCAT, Pierre Jaunet's Flying Boat, a 1943 Catalina which lands and takes off on both land and water. The itinerary for our amphibious safari is almost set and those who appreciate really unusual adventure should watch for it in their mail.

Mondays at the Museum

A new lecture series for the Friends of the MCZ and Museum Guides featuring various members of the museum staff was launched on November 5 with *Beautiful, Bizarre, and Beastly Beetles* by Dr. David Furth, Curatorial Associate in Entomology, in conjunction with the opening of *Return of Beetlemania!*

Future speakers and topics:

January 7: *Classic Maya Civilization in the Computer Age*

New advances in computer technology have greatly facilitated the study of Maya archaeological sites. Dr.Rosemary Joyce, Assistant Professor in the Department of Anthropology and Assistant Curator of pre-Columbian Archaeology will discuss how Maya sites are organized and the role computers play in conveying this to students.

February 4: *Trends in Island Demography*

Animals that live on islands may appear to be identical to their mainland relatives but in fact many species live longer, have fewer offspring, and reach puberty at different ages. The reasons for this will be discussed by Dr. Steven Austad, Associate Professor of Biology.

March 4: *Dinosaur Hunting in Greenland*

Dr. Farish A. Jenkins, Jr., Professor of Biology, Curator of Vertebrate Paleontology in the MCZ, and Professor of Anatomy at Harvard Medical School will describe how, against all odds, the MCZ Paleontogocial Expeditions to arctic Greenland in 1988 and 1989 unearthed the remains of an ancient fauna that flourished in a subtropical climate 200 million years ago.

Lectures take place at 5:30 on the first Monday of each month in Haller Hall, Geological Museum, 24 Oxford Street. Admission is free and limited to Friends of the MCZ, Museum Guides, and staff members.

Museum Education Program

This year we are emphasising our outreach efforts to members of the surrounding community directly as opposed to working through the Cambridge Schools as we have done for the past eight years. With Maureen Stephens, Museum Education Coordinator, at the helm, the results have been extremely gratifying.

Wish List

We are currently in the process of developing education programs for the new Native American Hall. We would be interested in obtaining any Native American resources or teaching materials that anyone can loanus on a semi-permanent basis. We are especially interested in resource materials such as books and magazines and in hands-on teaching materials such as tools, clothing, games, toys, posters, and pictures. If you have something that might be useful for this program, please call Maureen Stephens at 495-2341.

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